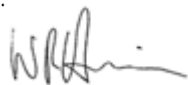


 Weatherford®	INSPECTION SPECIFICATION					
	REV: R	SECTION: Testing	NUMBER WT-811	Prepared by: R. Barreto	PAGE 1	APPROVAL: 
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions					DATE: 9/16/2025	

1.0 SCOPE

- 1.1** This specification pertains to magnetic particle inspection (MPI). The primary method is the continuous wet fluorescence. The secondary methods are the visible non-fluorescence wet and dry method. The visible method is used when it is not practical to use the primary methods. This inspection technique is applicable to ferromagnetic materials such as carbon and low alloy steels and the martensitic family of stainless steels.
- 1.2** This inspection instruction contains default acceptance criteria and inspection instructions. The acceptance criteria and location specific instructions that are specified in the applicable Weatherford Testing/Quality or material specification and customer requirements supersede those defined herein. When inspecting equipment applicable to the below API documents this inspection specification shall be used in conjunction with WT-101 “Wet Magnetic Particle Inspection API Specification 6A, 11D1, 14A, 14L, 16A, 16C and 19V Type Acceptance Criteria”.
- 1.3** The industry specifications referenced in Section 2.0 shall be the latest revision level.

2.0 REFERENCED SPECIFICATIONS

- 2.1** AMS 3041: Magnetic Particles, Nonfluorescent, Wet Method, Oil Vehicle, Ready-to-Use
- 2.2** AMS 3042: Magnetic Particles, Nonfluorescent, Wet Method, Dry Powder
- 2.3** AMS 3043: Magnetic Particles, Nonfluorescent, Wet Method, Oil Vehicle, Aerosol Packaged
- 2.4** AMS 3044: Magnetic Particles, Fluorescent, Wet Method, Dry Powder
- 2.5** AMS 3045: Magnetic Particles, Fluorescent, Wet Method, Oil Vehicle Ready-to-Use
- 2.6** AMS 3046: Magnetic Particles, Fluorescent, Wet Method, Oil Vehicle, Aerosol Packaged
- 2.7** ASNT SNT-TC-1A: Personnel Qualification and Certification in Nondestructive Testing
- 2.8** ASTM E709: Guide for Magnetic Particle Examination
- 2.9** ASTM E1444: Standard Practice for Magnetic Particle Examination
- 2.10** ASTM E3024: Standard Practice for Magnetic Particle for General Industry
- 2.11** ISO 9712: Non-destructive testing – Qualification and certification of NDT personnel
- 2.12** ISO 10893-5: Non-destructive testing of steel tubes Non-destructive testing of steel tubes — Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections.
- 2.13** Weatherford Specification WT-101: Wet Magnetic Particle Inspection API 6A, 11D1, 14A, 14L, 16A, 16C and 19V Type Acceptance Criteria
- 2.14** Weatherford Specification WT-052: Wellhead Equipment Inspection Requirements
- 2.15** Weatherford Specification WT-801: Written Practice for the Qualification and Certification of Non-Destructive Testing Personnel

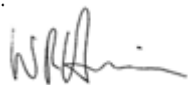
3.0 PERSONNEL QUALIFICATIONS

- 3.1** All personnel performing magnetic particle inspection shall be qualified in accordance with the guidelines set forth by ASNT-SNT-TC-1A, ISO 9712 or a national or international standard that is equivalent to ISO 9712 or ASNT SNT-TC-1A. A level I may perform all parts of the inspection process except evaluation. A level II and III may perform all parts of the inspection process to include

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 Weatherford®	INSPECTION SPECIFICATION					
	REV: R	SECTION: Testing	NUMBER WT-811	Prepared by: R. Barreto	PAGE 2	APPROVAL: 
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions					DATE: 9/16/2025	

evaluation, and is responsible for interpretation of the codes, training of level I, and giving verbal or written instructions to a level I.

An eye examination shall be given to all personnel at time of initial certification and shall meet the requirements of WT-801. The Near-Distance acuity shall be repeated annually and the Color Contrast examination at a maximum of five years thereafter.

Note: see Appendix A for a list of companies that require personnel qualification to ISO 9712.

4.0 EQUIPMENT LIST

- 4.1 Fluorescent Wet Magnetic Particles: petroleum or water base
- 4.2 Non-Fluorescent Wet Magnetic Particles and background paint
- 4.3 Dry Magnetic particles
- 4.4 100 ml Centrifuge Tube and stand
- 4.5 Magnetic Particle Field Indicators: Flexible Laminated Strips, Magnetometer, QQI shims
- 4.6 Black Light
- 4.7 Ultraviolet/White Light Meter
- 4.8 Black Light booths or Tarps
- 4.9 Magnetic coils and or Cable Wraps
- 4.10 AC/DC Yokes
- 4.11 Magnifying Mirror

Note: The above equipment shall conform to the following requirements of 5.0

5.0 SYSTEMS PERFORMANCE AND EQUIPMENT REQUIREMENTS

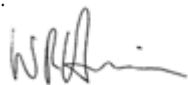
5.1 Wet Magnetic Particles Solution

- 5.1.1 Wet magnetic particles properties and size shall meet the AMS specifications for the following forms: AMS 3041: Magnetic Particles, Nonfluorescent, Wet Method, Oil Vehicle, Ready-to-Use. AMS 3042: Magnetic Particles, Nonfluorescent, Wet Method, Dry Powder. AMS 3043: Magnetic Particles, Nonfluorescent, Wet Method, Oil Vehicle, Aerosol Packaged. AMS 3044: Magnetic Particles, Fluorescent, Wet Method, Dry Powder. AMS 3045: Magnetic Particles, Fluorescent, Wet Method, Oil Vehicle Ready-to-Use. AMS 3046: Magnetic Particles, Fluorescent, Wet Method, Oil Vehicle, Aerosol Packaged.
- 5.1.2 The magnetic particles may be mixed in a water or petroleum base solution.
- 5.1.3 The water base solution must wet the surface without any visible gap. If incomplete coverage occurs, a new particle bath or the addition of more wetting agents may be necessary.
- 5.1.4 When a petroleum base solution is used it must not exhibit a natural fluorescent under a black light. Gasoline or diesel is not permitted.

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 Weatherford®	INSPECTION SPECIFICATION					
	REV:	SECTION:	NUMBER	Prepared by:	PAGE	APPROVAL:
	R	Testing	WT-811	R. Barreto	3	 DATE: 9/16/2025
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions						

- 5.1.5 Particle concentration of solution shall be checked with a 100 ml centrifuge tube and shall range from 0.1 ml to 0.4 ml for fluorescent and 1.2 ml to 2.4 ml for non-fluorescent after a settling time of 60 minutes for oil and 30 minutes for water. Manufacture lot test may be used in lieu of a settling test when using aerosol type particles. Particles shelf life shall not be expired.
- 5.1.6 The solution shall be agitated frequently during inspection and prior to validating the solution concentration.
- 5.1.7 The concentration of the solution shall be checked prior to use. The concentration of solution in a recirculating system shall be verified at least once during each eight-hour shift.
- 5.1.8 Caution shall be taken when spraying particles on the part. A high velocity stream may wash away indications. A fine mist spray is desirable.
- 5.1.9 Contamination of particles and carrier shall be checked at least weekly. Reference ASTM E709 section 20.6.4. Not required for aerosol.

5.2 Dry magnetic Particles

- 5.2.1 The color of the particles shall contrast to the parts surface.
- 5.2.2 The particles shall have a mixture size containing at least 75% being finer than 100 ASTM sieve size and a minimum of 15% being finer than 325 ASTM sieve size and/or meet the requirements of AMS 3040.
- 5.2.3 The reuse of dry particles is not allowed.
- 5.2.4 The particles shall be free of containments such as moisture, dirt, and sand.
- 5.2.5 The parts surface shall be dry (not damp to the touch) when applying particles.
- 5.2.6 Dry magnetic particle inspection should not be attempted when uniform application of the magnetic particles over the surface is not possible.

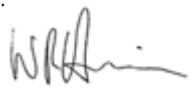
5.3 Visible Light Intensity

- 5.3.1 Visible light shall be used when examination is performed with non-fluorescent particles.
- 5.3.2 Visible light intensity shall be a minimum of 100 fc (1076 lux).
- 5.3.3 For some field examinations using nonfluorescent particles, visible light intensities as low as 50 fc (538 lux) may be used when agreed on by the contracting agency.

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 Weatherford®	INSPECTION SPECIFICATION					
	REV:	SECTION:	NUMBER	Prepared by:	PAGE	APPROVAL:
	R	Testing	WT-811	R. Barreto	4	
TITLE:					DATE:	
Wet Magnetic Particle Inspection – Inspection Instructions					9/16/2025	

5.4 Black Light

- 5.4.1 The black light shall be capable of producing a minimum of 1000 $\mu\text{w}/\text{cm}^2$ at 15 inches from the light source or at the inspection distance, whichever is greater.
- 5.4.2 The black light intensity shall be verified each time the light is turned on and after eight hours of continuous operation. Battery powered shall be checked before and after each use.
- 5.4.3 The black light meter shall be calibrated as recommended by the manufacturer but shall not exceed 6 months.
- 5.4.4 A black light with a mercury vapor bulb shall be allowed to warm up for a minimum of five minutes prior to examination. An LED type black light only needs to stabilize.
- 5.4.5 If using a booth or open area the ambient visible light intensity shall be verified not to exceed 20 lux (2fc) at the part surface.
- 5.4.6 The inspector shall allow one minute for dark area eye adaptation prior to viewing the part. Photochromic and darkened lenses are not allowed.
- 5.4.7 The UV-A lamps must be checked weekly and kept clean.

5.5 Magnetizing Current power supplies

- 5.5.1 Power supplies are used to adjust the amperage on a coil or magnetizing unit.
- 5.5.2 Power supplies shall have an ampere meter.
- 5.5.3 Amperage shall be monitored during each application.
- 5.5.4 The power supply shall periodically be calibrated.
- 5.5.5 Power supply shall have a serial number.

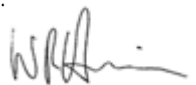
5.6 Coils/Cable Wrap

- 5.6.1 A coil induces a longitudinal field for the detection of transverse indications.
- 5.6.2 The part must be completely encircled by the coil.
- 5.6.3 For DC coils the magnetic field shall be verified as to the direction and the relative field strength using one or more of the following: Digital gauss meter, Magnetometer, shims and flexible laminated strip.
- 5.6.4 For AC coils the magnetic field direction shall be verified using a magnetic flux indicator strip and the relative field strength shall be measured using a digital gauss meter.
- 5.6.5 The turns and serial number shall be stenciled on the body of the coil.

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 Weatherford®	INSPECTION SPECIFICATION					
	REV: R	SECTION: Testing	NUMBER WT-811	Prepared by: R. Barreto	PAGE 5	APPROVAL: 
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions					DATE: 9/16/2025	

5.7 AC /DC Yoke

- 5.7.1 An AC yoke is used for surface breaking discontinuities.
- 5.7.2 A DC yoke is used for surface and near surface discontinuities.
- 5.7.3 An AC yoke must be capable of lifting 10 pounds at 2 to 6 inches pole spacing.
- 5.7.4 A DC yoke must be capable of lifting 30 pounds at 2 to 4 inches and 50 pounds at 4 to 6 inches pole spacing.
- 5.7.5 The yoke contact area must touch the surface and the magnetic field shall be positioned 90 degrees to the suspected direction of the imperfection.

5.8 Strength and Field direction of magnetizing equipment

- 5.8.1 The relevant field strength on the part shall be a minimum of 30 gauss. Increase the field strength as high as possible, but not so high as to cause masking of indications on the test piece. As an alternative shim type CX-230/ CX-430 or equivalent can be used to demonstrate field strength. CX-230 is normally placed on curved surfaces. Yoke magnetic field strength is verified by the lift test in 5.7. Direction of magnetic field shall be verified using flexible laminated strips or shims. Field strength and direction shall be checked prior to inspection and periodically not to exceed four hours as per ISO 10893-5.

5.9 Equipment calibration

- 5.9.1 Equipment calibration shall comply with ASTM E3024 Table 1 for calibration intervals and Section 7.4 requirements.

5.10 System Parameter Verification: A log or inspection report shall be maintained for the purpose of recording system verification data of the following when the test system is in operation.

- 5.10.1 The UV intensity of the Black Light daily. Refer to Section 5.4.2
- 5.10.2 Ambient light and visible light intensity weekly. Refer to Section 5.4.5 and Section 5.3
- 5.10.3 Water break test daily for particles suspended in water. Refer to Section 5.1.3.
- 5.10.4 Wet Particle concentration of solution daily. Refer to 5.1.5 Not required for aerosol spray.
- 5.10.5 Wet Particle Contamination weekly. Refer to 5.1.9. Not required for aerosol spray.
- 5.10.6 Field direction and strength daily. Refer to section 5.8.1.

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 Weatherford®	INSPECTION SPECIFICATION				
	REV: R	SECTION: Testing	NUMBER WT-811	Prepared by: R. Barreto	PAGE 6
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions					DATE: 9/16/2025

6.0 PART PREPARATION

- 6.1 Check the work order for client specific criteria or inspection method.
- 6.2 Clean and remove surface irregularities and foreign matter (rust, grease, thread compound) that will interfere with the inspection.
- 6.3 Surface coatings shall be smooth and have a thickness equal to or less than 0,05 mm (.002 in).
- 6.4 For threaded ends clean the entire machined area plus one inch.

7.0 PROCEDURE (Continuous Wet Fluorescent method is the primary Method)

7.1 Active Longitudinal field with a DC type coil or cable wrap.

- 7.1.1 Determine the polarity of the existing magnetic field if any. The coil shall be placed on the part so as to reinforce (not oppose) the field already present. If using a cable wrap, use 3 to 5 turns with an ID slightly larger than the parts OD.
- 7.1.2 With the coil on apply the magnetic particle solution. The coil shall remain on for at least 2 seconds after the solution has been distributed.
- 7.1.3 Magnetic field strength shall be verified with a magnetometer (gauss meter) or QQI shims. Laminated strips are only used to verify filed direction.
- 7.1.4 Examine the part with a black light.
- 7.1.5 Reposition the part and or coil and Repeat 7.1.2 through 7.1.4 as necessary to assure 100% coverage.

7.2 Active longitudinal field with an AC Coil

- 7.2.1 Place the coil over the examination area.
- 7.2.2 Energize the Coil, apply solution, allow 3 seconds for suspected indications to form.
- 7.2.3 Conduct the examination with a black light.
- 7.2.4 Examination area is under the coil and 3 inches on each side
- 7.2.5 Reposition the coil or part and repeat 7.2.2 through 7.2.4 as necessary to ensure 100% full length coverage.

Note: An AC coil is for surface inspection only. It is not allowed for MPI inspection of the I.D.

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 Weatherford®	INSPECTION SPECIFICATION				
	REV: R	SECTION: Testing	NUMBER WT-811	Prepared by: R. Barreto	PAGE 7
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions					DATE: 9/16/2025

7.3 Active Field with a Yoke

- 7.3.1 Place the yoke on the surface of the part so the magnetic field is positioned 90 degrees to the direction of the suspected indication.
- 7.3.2 Energize the yoke, apply solution, allow 3 seconds for indications to form. Examine the area with a black light.
- 7.3.3 Reposition the yoke to allow for overlap and repeat 7.3.1 through 7.3.2 as necessary to assure 100% coverage.
- 7.3.4 Turn the yoke 90 degrees and repeat 7.3.2 through 7.3.3 as necessary to assure 100% coverage.

7.4 Active circular field by direct contact with a head shot or cable clamp.

- 7.4.1 Place the part in the head / tailstock or clamps on the part.
- 7.4.2 Initially, adjust the current to achieve the proper magnetic field strength and direction by verifying with QQI shims. As an option a gauss meter can be used for the field strength.
- 7.4.3 Energize the current, apply solution, allow at least three seconds for indications to form.
- 7.4.4 Examine the area where the bath was applied with a black light.
- 7.4.5 It may be necessary to perform the above in sections to achieve 100% coverage depending on the length and shape of the part. Refer to the manufacture for the maximum current and duration to prevent overheating of the machine.

Note: Multidirectional magnetization can only be performed with a magnetization unit designed for that particular purpose. In addition, QQI shims must be used to balance the fields.

7.5 Active circular field by indirect induction with a central conductor

- 7.5.1 Place the insulated central conductor or cable through the part.
- 7.5.2 Initially, adjust the current to achieve the proper magnetic field strength and direction by verifying with a field strip indicator, gauss meter and or QQI shims.
- 7.5.3 Verification shall take place on the OD surface at the point furthest away from the central conductor.
- 7.5.4 Energize the current, apply solution to the OD, allow at least three seconds for suspected indications to form.

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 Weatherford®	INSPECTION SPECIFICATION				
	REV: R	SECTION: Testing	NUMBER WT-811	Prepared by: R. Barreto	PAGE 8
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions					DATE: 9/16/2025

- 7.5.5 Examine the area where the bath was applied with a black light.
- 7.5.6 Rotate the part as necessary and repeat 7.5.4 through 7.5.5 to assure 100% coverage on the OD.
- 7.5.7 Again, energize the current, apply solution to the upper half of the ID, allow three seconds for the indications to form.
- 7.5.8 Examine the area where the bath was applied with a black light.
- 7.5.9 Rotate the part 180 degrees and repeat 7.5.7 through 7.5.8. Until 100% coverage is achieved.
- 7.5.10 It may be necessary to perform the above in sections to achieve 100% coverage depending on the length and shape of the part. Refer to the manufacture for the maximum current and duration to prevent overheating of the machine.

Note: It may be more practical depending on the length and shape to perform the above with a residual field.

8.0 PROCEDURE (Secondary Methods)

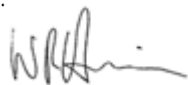
8.1 Residual Longitudinal Field with Dry or Wet Visible Method

- 8.1.1 Only DC type current is allowed to induce a residual field. Place the coil or cables in such a way as to reinforce any existing residual field.
- 8.1.2 Select a powder that has a high color contrast to the part being examined.
- 8.1.3 The magnetic field strength must be of sufficient strength to indicate those discontinuities which are unacceptable, however must not be so strong that an excess of particles is accumulated locally thereby masking relevant indications.
- 8.1.4 After magnetizing verify the relative field strength and direction with a magnetometer and magnetic flux strip or QFI.
- 8.1.5 If using dry particles, apply by gently floating the particles to the parts surface in a light cloud. Examine while applying the particles.
- 8.1.6 If using wet particles apply by flowing or a low pressure mist spray. Allow 3 seconds for indications to form prior to examination.
- 8.1.7 Inspection area shall have a minimum of 100 fc of white light for the OD surface and 100 fc for the ID surface.

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 Weatherford®	INSPECTION SPECIFICATION					
	REV:	SECTION:	NUMBER	Prepared by:	PAGE	APPROVAL:
	R	Testing	WT-811	R. Barreto	9	 DATE: 9/16/2025
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions						

8.2 Active Dry or wet Visible method with an AC/DC Yoke

- 8.2.1 Place the yoke on the surface of the part so the magnetic field will be 90 degrees to the direction of the suspected indication.
- 8.2.2 Perform magnetization using the continuous method by applying the yoke in the active mode while simultaneously applying the dry or wet magnetic particles.
- 8.2.3 If using dry particles apply by gently floating to the parts surface in a light cloud. Examine while applying the particles.
- 8.2.4 If using wet particle apply by flowing or a low pressure spray. Allow at least three seconds for indications to form. Examine with the current on.
- 8.2.5 Reposition the yoke to allow for overlap and repeat the above as necessary to assure 100% coverage.
- 8.2.6 Turn the yoke 90 degree's and repeat the above as necessary to assure 100% coverage in the opposite direction.
- 8.2.7 Inspection area shall have a minimum of 100 foot candles of white light for the OD surface.

8.3 Active Dry or Wet Visible method with AC Coil

- 8.3.1 Place the coil over the examination area. Effective field strength of the AC coil is 3 inches on each side of the coil.
- 8.3.2 Perform magnetization using the continuous method by applying the AC coil in the active mode while simultaneously applying the dry or wet magnetic particles.
- 8.3.3 If using dry particles apply by gently floating to the parts surface in a light cloud. Examine while applying the particles.
- 8.3.4 If using wet particle apply by flowing or a low pressure mist spray. Allow at least three seconds for indications to form. Examine with the current on.
- 8.3.5 Reposition the coil and or part and repeat the above as necessary to assure 100% coverage.

8.4 Residual circular field with wet or Dry for tubular goods

- 8.4.1 Only DC type current is allowed to induce a residual field.
- 8.4.2 Place the insulated central conductor or cable through the tube. Assure the tubulars are insulated from the racks. The tube being magnetized shall be separated 36 inches from adjacent tubulars.

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 Weatherford®	INSPECTION SPECIFICATION				
	REV: R	SECTION: Testing	NUMBER WT-811	Prepared by: R. Barreto	PAGE 10
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions					DATE: 9/16/2025

- 8.4.3** If using a capacitor discharge unit, apply at least the minimum recommended current per API 5A5 table A 11 or ASTM E 709 table X8.1 magnetization of oilfield tubulars.
- 8.4.4** If using a rectified AC power supply (HWDC, FWDC), apply at least 300 amps per inch of specified outside diameter.
- 8.4.5** Verify the minimum current is achieved during each application.
- 8.4.6** Remove the central conductor or cable
- 8.4.7** Apply particles to the OD and ID and examine using the residual field.
- 8.4.8** Remove all particles from the ID and OD.

9.0 EXAMINATION AREA

- 9.1** The inspection area surfaces that are specified on the applicable product quality plan, purchase order or engineering document shall be 100% inspected. When no specific surfaces have been defined, all accessible surfaces shall be wet fluorescent magnetic particle inspected after final heat treatment and final machining operations. Special attention shall be given to abrupt changes in surfaces such as sharp radius, tapers, groves, holes, cuts, and any other area that is suspect of being a stress riser.

10.0 RELEVANT INDICATIOS

- 10.1** Unless otherwise specified in the relevant Weatherford Materials Specification, only those indications with major dimensions greater than 1/16" (1.6mm) and associated with a surface rupture shall be considered relevant. Inherent indications not associated with a surface rupture but do result in magnetic permeability variations such as nonmetallic inclusions are considered nonrelevant. If these indications exhibit a relevant size but are believed to nonrelevant, they shall be examined by liquid penetrant surface NDE or removed and re-inspected to determine relevancy.
- 10.2** For equipment applicable to the following API documents, classification of indications shall be as stated in WT-101 Wet Magnetic Particle Inspection API Specification 6A, 11D1, 14A, 14L, 16A, 16C and 19V Type Acceptance Criteria".

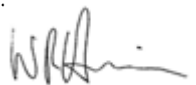
11.0 ACCEPTANCE CRITERIA

- 11.1** Acceptance criteria: Unless otherwise specified in the relevant Weatherford Material Specification or other specified engineering specifications or drawings the acceptance criteria is as follows: (1) no relevant linear indications, (2) no relevant rounded indications equal to or greater than 3/16" (4.8mm), (3) four or more rounded indications in a line separated by less than 1/16" (1.6 mm) measured edge to edge are unacceptable and (4) no more than 10 relevant indication in any continuous 6 square inches (39 square cm) area.

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 Weatherford®	INSPECTION SPECIFICATION					
	REV: R	SECTION: Testing	NUMBER WT-811	Prepared by: R. Barreto	PAGE 11	APPROVAL: 
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions					DATE: 9/16/2025	

- 11.2 Linear Indication: any indication whose length is equal to or greater than three times its width.
- 11.3 Round Indication: any indication which is circular or elliptical and whose length is less than three times its width
- 11.4 For equipment applicable to the following API documents, acceptance is to the Wet Magnetic Particle Inspection API Specification 6A, 11D1, 14A, 14L, 16A, 16C and 19V Type Acceptance Criteria”.

12.0 EVALUATION OF INDICATIONS

- 12.1 Evaluate all relevant indications with respect to this specification and the applicable standard. All relevant indications shall be re-processed to confirm relevant.
- 12.2 Any non-relevant or false indication that could mask a relevant indication is unacceptable.

13.0 POST CLEANING AND DEMAGNETIZATION

- 13.1 Demagnetize to 10 gauss or less measured with an electronic gauss meter or 5 gauss or less measured with a magnetometer.
- 13.2 Remove magnetic particles from the part. Pay extra attention to bare metal surfaces.
- 13.3 Parts with threaded connections shall have a rust preventative applied and thread protectors.

14.0 MARKING

- 14.1 Place a stamp, stencil or tag to the part to identify the status; when a Weatherford facility has an applicable marking or processing procedure, the status shall be identified using that procedure. If a more detailed marking system is required, the user shall have documented marking instructions.

15.0 REPORTING

- 15.1 Part number if applicable and description of equipment inspected
- 15.2 Type of inspection performed
- 15.3 Type of carrier used
- 15.4 Demagnetization method used
- 15.5 Job/work order number and quantity of parts
- 15.6 Serial number if applicable traceable to the part and MPI report
- 15.7 Date of examination
- 15.8 Add printed name, signature and certification level of technician
- 15.9 Applicable acceptance criteria
- 15.10 Accept or Reject
- 15.11 Sketch identifying any unacceptable defects or unusual patterns

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 Weatherford®	INSPECTION SPECIFICATION				
	REV: R	SECTION: Testing	NUMBER WT-811	Prepared by: R. Barreto	PAGE 12
TITLE: Wet Magnetic Particle Inspection – Inspection Instructions					DATE: 9/16/2025

- 15.12 Sketch drawn by the inspector indicating MPI coverage when a part is not able to be 100% inspected
- 15.13 Specify particle “type”, e.g. AMS-3043
- 15.14 Customer information if applicable

Review and Approved by: 
Michael Jennette
ASNT Level III, MP, LP, UT, VT MFL, Cert # 114633

Uncontrolled unless stamped with a RED “Q”.

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REV: R	SECTION: Testing	NUMBER WT-811	Prepared by: R. Barreto	PAGE 13	APPROVAL:
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Wet Magnetic Particle Inspection – Inspection Instructions

9/16/2025

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